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Evaluation and Biological properties maps of Gypsiferous Soil using Geomatic techniques, Tikrit city, Salahaldin, Iraq

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Evaluation and Biological properties maps of Gypsiferous Soil using Geomatic techniques, Tikrit city, Salahaldin, Iraq

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Abstract

This study was conducted to prepare a map of the biological properties in the gypsiferouse soil using geomatic techniques at the Tikrit city site. (20) soil samples of the surface layer of gypsum soil were collected randomly according to differently in the nature of agricultural exploitation as survey study. Analyses and measurements of physical (texture and bulk density) and chemical characteristics were carried out: pH, EC, O.M, $CaSO_4.2H_2O$ and the bacteria and fungi numbers were estimated by methods Certified in the laboratory. Used satellite Images acquired at 24Feb.2019 and 20sep.2019 were used and processed digitally and calculated the following vegetation indicators as follows: NDVI, OSAVI, LAI and LST. Maps of the biological properties (Bacteria and Fungi) were prepared using the Kriging interpolation according to The Spheroidal Model in the ArcGIS Ver environment.10.2. The show results the effect of gypsum content in the bacteria and fungi with the R^2 (0.75 and 0.79). The results reached the importance of indices in evaluating the state and activity of bacteria as a positive regression relationship between the NDVI, LAI and OSAVI with the numbers of bacteria and fungi range (0.49 - 0.80) and were negative regression with the earth's surface temperature LST . Therefore, spectral indices has proved important in spatial forecasting of the distribution and activity of organisms and the control of seasonal changes in soil surface.

Key words: Remote Sensing, Kriging tool, Land Surface Temperature, microbiology activity, gypsiferours soil.

1. Introduction

The area of the gypsiferous soils in Iraq 88,000 km2 (20)% of Total Iraq's area. The areas which its occopies from south of Sinjar in Ninevah governorate and even southern Iraq. The AL-Jazeera soils (gypsiferous) in Salaaldine city suffer from many problems such as poor fertility, weak structure, the presence of hard pan layer and salinity. There is an urgent need to carry out numerous studies in the field of biology characteristics of Gypsiferious Soil and to identify the activity of these organisms as they are factors that help plant growth and increase production [1]. The soil which is contain more than 5% gypsum (calcium sulfate) in the active root layer call gypsiferous soil [2]. Therefore, it is necessary to study these soils from various aspects, as the gypsum soil suffers from several problems as decreasing water retention, organic matter content, CEC , nutrient supply and microbial activity [3]. Gypsum particles replace clay content, which weakening of its biological activity. Biomass is found in indigenous organisms, which are organisms whose numbers remain fairly constant and are not affected much by the different coefficients of the soil, whose native and permanent habitat is the soil and has a key role in the changes that occur within the soil (chemical and biological).

Remote sensing are one of the most important modern technologies that can monitor a wide area and with extreme accuracy, through spectral reflectance calculate, Biological crust, spectral indices, temperature Earth's surface calculation and plant density monitoring using spectral indices with direct and indirect effect on microorganism on a scale Large and highly efficient spaces [4]. [5] illustrated that the use of remote sensing programs and GIS is one of the modern technologies that showed compatibility in the results of field surveys with the results of the data obtained from the ERDAS program and the maps produced in GIS that depend on remote sensing data. Several studies have provided indices confirming that spatial interpolation techniques (kriging and IDW) has been successfully used to predict spatial changes of soil properties [6] and [7]. [8] mentioned The possibility of adopting satellite data in producing digital soil maps, as it is possible to derive a large number of spectral parameters within mathematical formulas to predict important soil characteristics related to soil degradation. In addition, most studies of spatial variations, whether for soil characteristics or other environmental phenomena, are carried out with statistical software that produces its outputs in the form of graphic profiles. The adoption of comprehensive software such as GIS achieves a realistic correlation between the values of the characteristics and the nature

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of their distribution on the ground when making spatial prediction. Digital, coordinate defined. [9] Results of the proposed indicators CNI, CSDI, CI, BSCI and spectral ratios, they were very important in monitoring changes in the biological crust. The study therefore aimed to link the relationship between gypsum content and microorgansim activity with spectral data and prepare to maps biological properties using spatial interpolation techniques.

2. Materials and Methods

2.1. Study area

The study area is located in the administrative boundaries of Tikrit city, Salahaldine Governorate, Iraq between (43°39'27.954"43°36'9.913"E) and (E 34°42'35.68"N34°39'28.655"N). The study area is about 16.11 km^2 and the height of sea level is 119 m (Figure 1). The climate condition are arid and semi-arid, low rainfall (less than 250 mm) and temperatures are high in summer (> 40) C˚. The slope degree of the study area range between level to semi-level (<2%) according Digital Elevation Model (DEM).

While, the area soils are classify at the great group level as calcigypsid according to Soil Survey Staff(2006). The nutrient content, weak structure, available water and poor with organic matter. The nature of agricultural exploitation prevailing in the region is the cultivation of wheat in winter and vegetable and maize crops in the summer. The (20) Twenty of soil samples were collected on 25sep 2019, distributed over the study area and depth(0-15). The Global Ground Position (GPS Gmini) was used in point delineation.

2.2. Laboratory working.

Electrical conductivity (EC) and soil reaction (pH) were measured by soil extract (1:1) [11]. The gypsum content was determined, according to [12].The organic matter was estimated according to [13].The second part was used for the purpose of conducting biological analysis, as it used the method of fear and counting by dishes. Using nutrient agar to estimate the number of total bacteria, and used the method of counting with dishes using the P.D.A medium to estimate the number of total fungi [14]. The percentage of VAM infection assaying with Root plant staining technique for arbuscular-mycorrhizal fungi (29) and assaying the number Spores of mycorrhizal Endogene species extracted from soil by wet-sieving and decating (30)

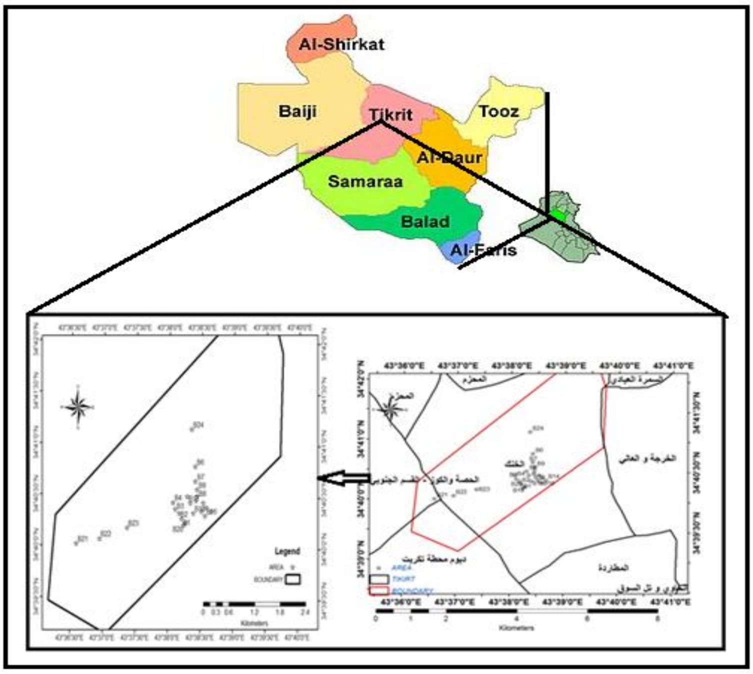

Figure 1. Study area.

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2.3. Remote Sensing and GIS

2.3.1. Satellite Images

The satellite image were obtained from the USGS website and ecquired on 24 Feb, 2019 and 20 sep, 2019 by Landsat 8, LOI, and digital processing of spectral bands 2 to band 7 was carried out according to Equations (1 and 2):

$$P'_{\lambda}=Mp\times Qcal+Ap \qquad (1)$$

P'_{λ}=TOA Planetary Spectral Reflectance.
Mp=Reflectance multiplicative scaling factor for the band (Metadata file)
Qcal. =Pixel value in DN for band2 to band 9.
Ap= additive rescaling factor (Metadata file).

$$P_{\lambda}=\frac{P'\lambda}{Sin(\theta)} \qquad (2)$$

Pλ=TOA planetary reflectance.
*Sin (θ) =Local sun elevation angle; the scene center sun \elevation angle in degrees is provided in the metadata File (Sun Elevation ×3.14/180).
The digital processor for calculating the Land Surface Temprature-LST. The digital processing of the package has been performed(10) In order to calculate the earth's surface temperature index, which is one of the evidence that helps us to evaluate the activity of microbiology in the gypsum soil and as in equations (1 and 2).

$$L\lambda = ML\times Qcal + AL \qquad (3)$$

Lλ = Spectral radiance (W/(m^2 * sr * μm)
ML: Radiance multiplicative scaling factor for the bands (from the metadata)
AL = Radiance additive scaling factor for the bands (from the metadata) **.**Qcal = Level 1 pixel value in DN

- Atmosphere brightness temperature

$$TB = \left(\frac{K2}{1+\left(\frac{K1}{L\lambda}+1\right)}\right)-273.15 \qquad (4)$$

TB=Top of atmosphere brightness temperature (C°) where
K1, K2: Band-specific thermal conversion constant from the metadata (K1: constant of band 10, where x is the thermal band number) thermal band conversion constant from the metadata (K2: constant of band 11).
Lλ=TOA spectral radiance (Watts / (m^2 ×srad × μm))

$$Pv = \left[\frac{NDVI-MinNDVI}{MaxNDVI-MinNDVI}\right]^2 \qquad (5)$$

P_v: Vegetation proportion.

$$\varepsilon = 0.004 \times Pv + 0.986 \qquad (6)$$

ε: Emissivity

$$LST = \frac{TB}{1+(L\lambda\times\frac{TB}{14380})\times LN(\varepsilon)} \qquad (7)$$

LST. Land Surface Temprature.

2.3.2. Spectral Indices.

The spectral indices were used for monitoring of plant status and its effect in bacteria and fungi activity in gypsiferous soil as follows**:**

Table 1. Spectral indices used in the study.

No.	Indices	Formula	Reference
1	Normalized Difference Vegetation Index	$NDVI = \frac{(B5-B4)}{(B5+B4)}$	[15]
2	Optimised soil Adjusted Vegetation Index	$OSAVI = \frac{(B5-B4)}{(B5+B4+0.1)}$	[16]
3	Leaf Area Index	$LAI=\frac{-LN(\frac{0.69-SAVI}{0.59})}{0.91}$	[17]

3. Result and Discussion

3.1. Chemical and physical properties

Table (2) show that the pH range (7.53-7.89) for the soil samples (B6, B12), respectively, and these results are agree with [18]. The electrical conductivity (EC) ranged (2.98, 2.21 and 2.21 dS.m^{-1}) for the soil samples (B6, B17, B5) respectively and are not consistent these results are with [20]. Gypsum soils are characterized by a low content of organic matter, show the results of a table (2) the organic matter range (6.2-13.0)g.Kg^{-1} for soil with gypsum content (12 and 5.5%) respectively, and these results are agree with [21], [22] and [23]. The soil samples were similar in the soil separates (sand, silt and clay). The sand content of the samples ranged between (488 and 725) g Kg^{-1}, while, the clay content reached its value (183 and 294) g. kg^{-1}. The results of soil texture have been influence by the gypsum content. Where, the decrease in clay content with the high percentage of gypsum because the gypsum soil originally has little clay content and tends to be poor sandy texture.

Table 2. the physical and chemical characteristics of the soil.

Sample symbol	Coordinate X	Coordinate y	EC dS.m^{-1}	pH	$CaSO_4.2H_2O$	O.M	Texture Sand	Texture Silt	Texture Clay
			dS.m^{-1}		gm kg^{-1}				
B1	3837446	375105	2.85	7.60	135.00	6.40	533.00	284.00	183.00
B2	3837543	375049	2.83	7.66	123.00	6.50	533.00	284.00	183.00
B3	3837621	374954	2.81	7.62	121.00	6.30	533.00	284.00	183.00
B4	3837739	374904	2.75	7.69	102.00	6.20	533.00	284.00	183.00
B5	3838261	3756525	2.21	7.73	56.00	12.00	588.00	228.00	184.00
B6	3838382	375431	2.98	7.89	210.00	12.90	588.00	228.00	184.00
B7	3838113	375435	2.96	7.71	195.00	12.10	588.00	228.00	184.00
B8	3837849	375475	2.91	7.83	145.00	10.00	588.00	228.00	184.00
B9	3837964	375474	2.26	7.75	31.00	12.50	488.00	278.00	224.00
B10	3837768	375450	2.29	7.89	87.00	10.70	568.00	238.00	194.00
B11	3837841	375244	2.34	7.81	45.00	10.80	578.00	238.00	184.00
B12	3837723	375613	2.38	7.53	55.00	13.00	725.00	74.00	202.00
B13	3837640	375692	2.36	7.67	65.00	8.00	614.00	92.00	294.00
B14	3837565	375799	2.59	7.82	61.00	9.30	612.00	155.00	233.00
B15	3837573	375575	2.25	7.69	22.00	8.20	614.00	92.00	294.00
B16	3837492	375659	2.82	7.81	122.00	9.40	612.00	155.00	233.00
B17	3837723	375316	2.21	7.62	22.00	8.70	612.00	155.00	233.00
B18	3837543	375380	2.29	7.81	44.00	9.50	612.00	155.00	233.00
B19	3837360	375196	2.75	7.84	85.00	9.10	612.00	155.00	233.00
B20	3837330	375145	2.91	7.82	115.00	9.60	612.00	155.00	233.00

The table (3) result presence of Mycorrhiza fungi spores in the soil and its numbers varied from region to region. The reason for the superiority Glomus mossea fungi compared to other fungi species may be attributed to the adaptation of this species in the Iraqi environment in terms of soil, plant and environmental condition [24].

There is a positive relationship between the numbers of spores and the percentage of infection with the percentage of the mycorrhiza infection, the size increases the fungi biomass and at the same time is reflected in the composition of the number of spores, so the difference in the number of spores can be attributed to the different numbers of spores. Therefore, the reason for the variation in the number of spores according to the different months and the host plant can be attributed to the difference in the percentage of infection. The relationship between the percentage of VAM infection and the number of spores on the one hand and the soil properties on the other hand. The studies have confirmed that the pH, calcium ion, moisture, organic matter and different ions are all factors affecting the fungi [25] and [26]. The results indicate to a positive relationship between VAM fungi and the pH, as the percentage of infection rises with a high pH. The cause of the growth of dendritic Mycorrhizae VAM in basal tending soils is due to the secretion of VAM fungi of some acids, especially oxalic. Which leads to a lowering of the pH that is suitable for the growth of VAM fungi [27]. The numbers of spores in the study area, and it is also apparent from the results that the incidence increased with the high percentage of calcium sulfate (gypsum) and calcium carbonate (lime). Noticed that the Tikrit area recorded the highest rate of infection with VAM fungi and this is due to calcium sulfate (gypsum) which reached (21%) and the lowest value of gypsum (2.2%) resulted in a decrease in the germination rate of Mycorrhizae spores and the rate of infection in the host plant.

Table 3. Soil boilogical properties (Bacterial, Fungi and Mycorrhiza).

Sample symbol	Bacteria x10^{-6}	Fungi x10^{-4}	Mycorrhiza spor/10g soil	Mycorrhiza % Root plant
B1	51.00	9.00	-	-
B2	28.00	8.00	-	-
B3	36.00	8.00	-	-
B4	23.00	13.00	-	-
B5	98.00	22.00	3	30
B6	51.00	8.00	2	20
B7	22.00	7.00	3	45
B8	25.00	9.00	1	-
B9	121.00	24.00	5	55
B10	22.00	13.00	-	-
B11	105.00	32.00	3	40
B12	118.00	26.00	2	55
B13	67.00	14.00	4	30
B14	82.00	15.00	3	30
B15	188.00	28.00	2	40
B16	32.00	8.00	1	-
B17	165.00	35.00	2	30
B18	78.00	12.00	3	20
B19	33.00	15.00	-	-
B20	22.00	12.00	-	-

The Fig (2, 3) results that show relationship between the bacteria and fungi activity with the soil gypsum content was negative R^2 (0.75 and 0.79) respectively. This demonstrates the results of a lot of research and studies that indicate the weakness of the biological activity in the gypsum because it is located within the regions arid and semi-arid, which is not suitable for most neighborhoods [3]. The lack of organic matter due to the dominant climatic conditions in the region, which help to oxidation of organic matter which its have been relationship with activity of bacteria and fungi [28].

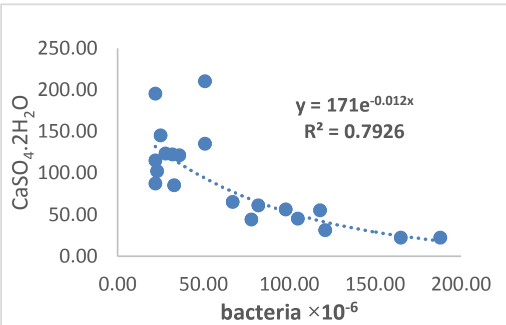

Figure 2. The relationship of negative regression between the bacteria activity and gypsum content.

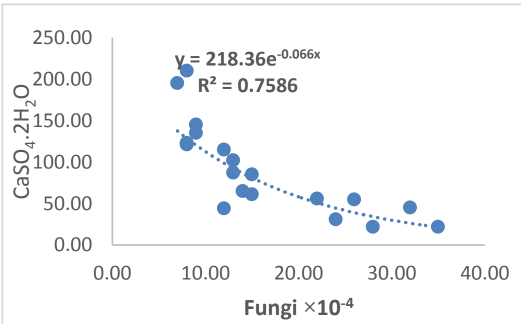

Figure 3. The relationship of negative regression between the activity of Fungi and gypsum content.

3.2. Spectral Indices Used to Monitor Microbiology Activity

The results of table (4) refers to the spectral indices used to assess the spatial relationship between vegetation status and microbiology activity. The NDVI is one of the most important indices, which use in the evaluation the state and density of vegetation and the extent to which soil management methods are use to maintain a healthy environment for plant growth and its effect on microorganisms and their activity. The NDVI ranging between 0.20-0.79 for each of the B15 and B15 samples. While, the number of bacteria at those samples range 22×10-6 and 188 × 10-6 this may be becuase role vegetation cover in the increase of microbial acivity through of bacteria and fungi numbers and its growth in gypsiferous soil environment. The Leaf Area Idex (LAI) is range between 1.69 as value highest and 0.50 as value lowest at the 24 Feb. 2019. That index have been a close relationship with the NDVI, as the higher the value gives us an indicator of plant density and protection of the soil surface from degradation and reduces evaporation rates and maintains the appropriate humidity level that encourages the activity of the microorganisms. The relationship between LAI and NDVI was positive regression and the value of the R^2 (0.62). The OSAVI is indicates a reduction in the effect of soil spectral reflectance on vegetation reflectance, ranging from 0.05 to 0.27. The Land Surface Temprature (LST), range between 19.44 and 47.75 C°, this may be because the highly gypsum content at B7 samples (195) $g.Kg^{-1}$. The relationship between the Earth's surface temperature index and NDVI was negative, with R^2 (0.51). The results of Figures (4 to 15) and table (4) showed the seasonal changes of the spectral indices at 24 February and 20 September 2019, and show that seasonal changes have a clear effect in the assessment of the state and density of vegetation. This is factors may be affect on microbiology activity, additionally, gypsum content, organic matter and another soil condition. The spectral indices NDVI, OSAVI and LAI are high in February compard with september.While, The LST in February month range between 14.10 and 19.44 while high in September month.

Table 4. Spectral Indices used to monitor the status and density of vegetation.

Sample symbol	NDVI		LAI		OSAVI		LST	
	24 Feb	20sep	24 Feb	20sep	24 Feb	20sep	24 Feb	20sep
B1	0.52	0.09	0.64	0.175	0.17	0.09	17.87	45.22
B2	0.38	0.081	0.50	0.116	0.12	0.072	16.83	45.08
B3	0.48	0.086	0.63	0.168	0.15	0.085	16.69	44.89
B4	0.20	0.085	0.53	0.132	0.04	0.087	16.5	43.39
B5	0.56	0.087	1.51	0.268	0.24	0.181	15.25	43.01
B6	0.52	0.10	0.78	0.193	0.16	0.106	17.91	46.69
B7	0.23	0.11	0.52	0.116	0.08	0.106	19.44	47.75
B8	0.24	0.101	0.50	0.109	0.09	0.104	17.38	45.69
B9	0.66	0.082	1.65	0.345	0.21	0.162	14.29	41.00
B10	0.45	0.11	0.97	0.221	0.13	0.107	16.68	43.58
B11	0.64	0.105	1.59	0.316	0.21	0.136	15.17	42.73
B12	0.74	0.110	1.62	0.33	0.24	0.157	15.21	43.03
B13	0.57	0.087	0.81	0.259	0.17	0.105	15.53	43.9
B14	0.62	0.112	0.91	0.245	0.19	0.139	16.20	44.31
B15	0.79	0.09	1.69	0.368	0.25	0.163	14.02	40.63
B16	0.32	0.11	1.24	0.233	0.15	0.125	16.76	44.66
B17	0.72	0.089	1.66	0.312	0.27	0.193	14.10	41.86
B18	0.54	0.085	0.79	0.193	0.11	0.105	15.22	44.74
B19	0.34	0.082	0.50	0.113	0.05	0.074	16.16	44.34
B20	0.22	0.081	0.67	0.141	0.05	0.082	16.36	44.05

The results of figurs (16 to 23) indicate the statistical regression relationship between the number of bacteria, fungi and spectral indices, as a positive regression relationship between spectral indices and the numbers of bacteria was observed, with the values of the R2 (0.80, 0.66 and 0.66) for NDVI, LAI and OSAVI, respectivily. While, the relationshipe between fungi and spectral indices, was positive the with R2 (0.49, 0.77 and 0.64) respectively. while, with the temperature of the earth's surface(LST) was negative regression with the R2(0.68 and 0.69) for bacteria and fungi, respectivily.

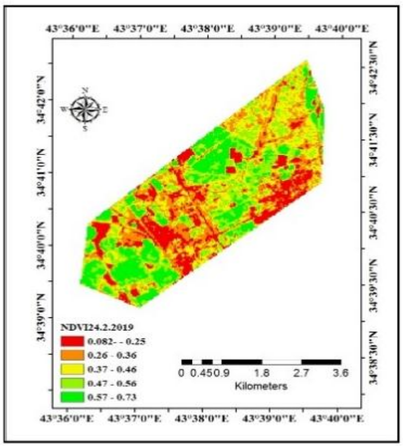

Figure 4. NDVI at 24 February 2019.

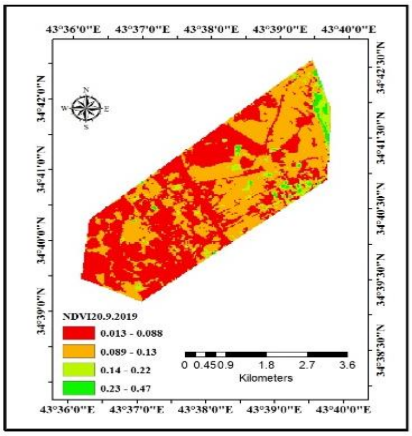

Figure 5. NDVI at 20 September 2019

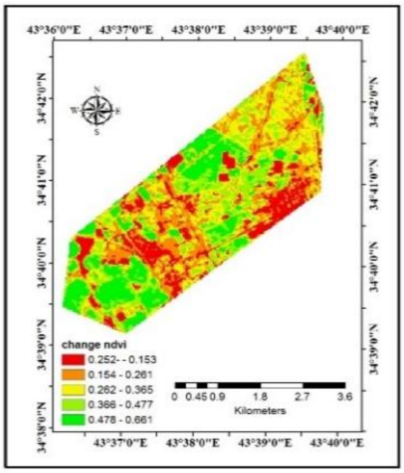

Figure 6. changes NDVI at 24 Feb. 20 Sep. 2019

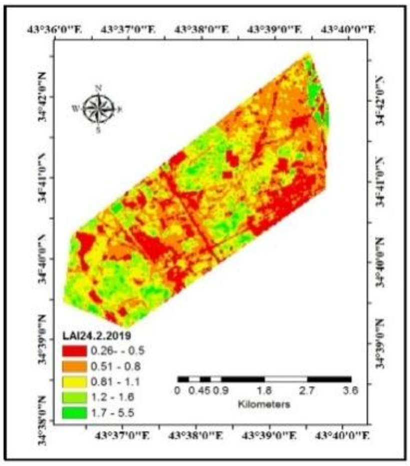

Figure 7. LAI calculated at 24 February 2019.

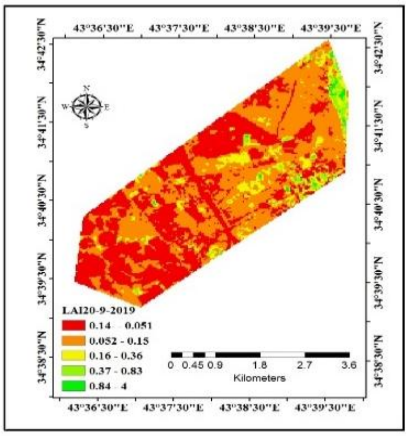

Figure 8. LAI at 20 Sep. 2019..

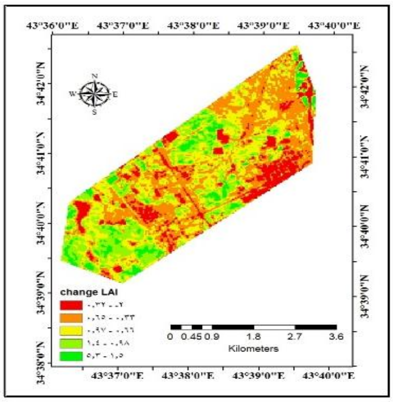

Figure 9. changes LAI at 24 Feb. 20 Sep. 2019

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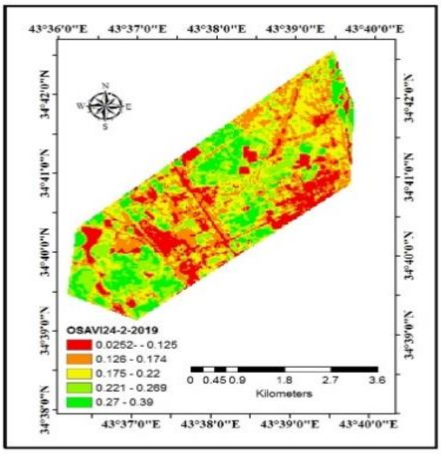

Figure 10. OSAVI at 24 February 2019.

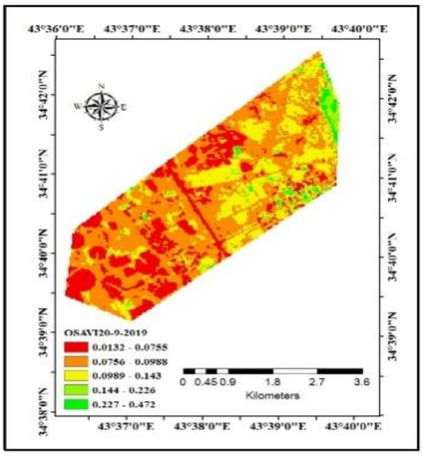

Figure 11. OSAVI at 20 September 2019.

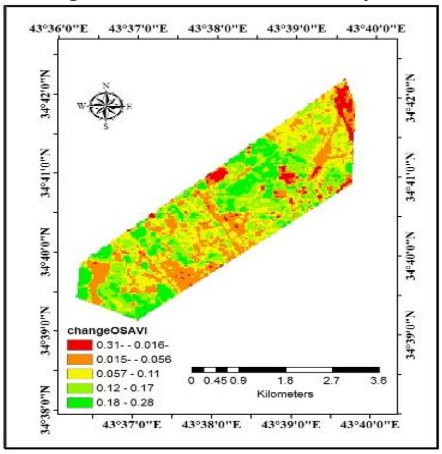

Figure 12. changes OSAVI at 24 Feb. 20 Sep. 2019

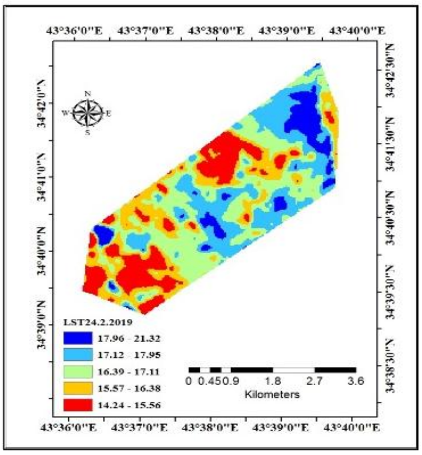

Figure 13. LST at 24 February 2019.

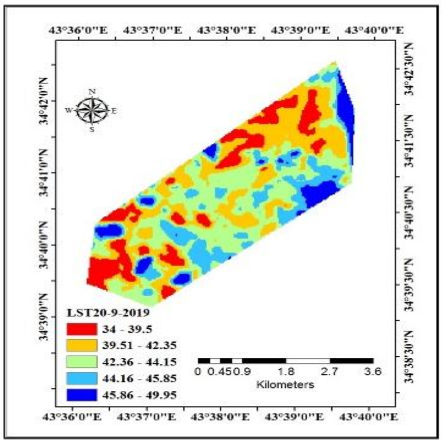

Figure 14. LST at 20 September 2019.

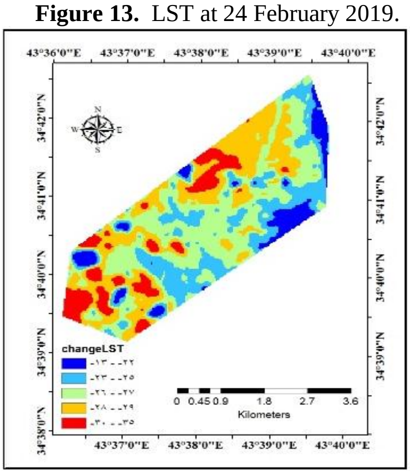

Figure 15. changes LST at 24 Feb. 20 Sep.2019.

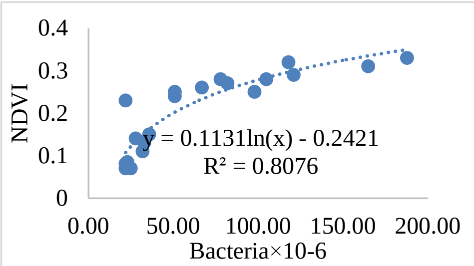

Figure 16. Exponential regression between NDVI and bacteria at 20 September 2019.

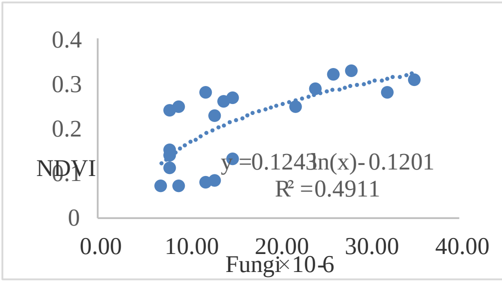

Figure 17. Exponential regression between NDVI and fungi at 20 September 2019.

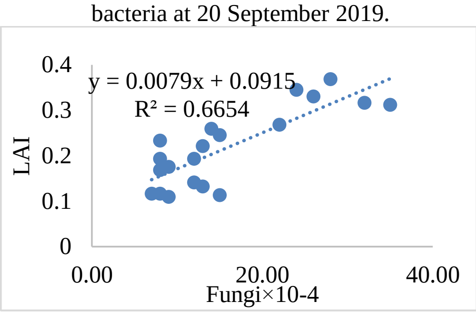

Figure 18. Exponential regression between LAI and bacteria at 20 September 2019.

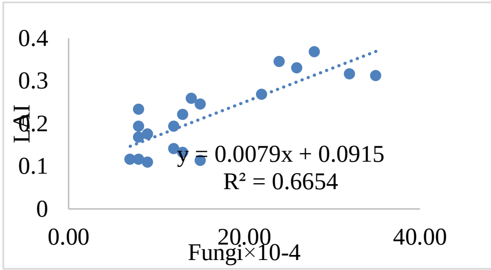

Figure 19. Exponential regression between LAI and fungi at 20 September 2019.

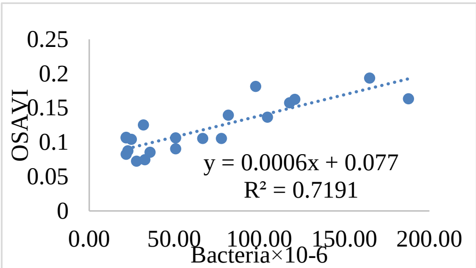

Figure 20. Exponential regression between OSAVI and bacteria at 20 September 2019.

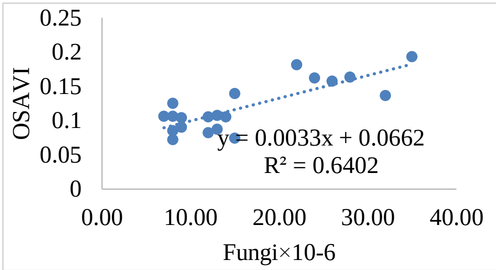

Figure 21. Exponential regression between OSAVI and fungi at 20 September 2019.

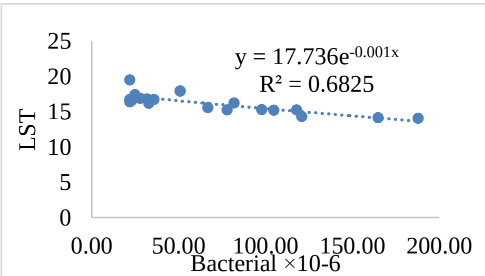

Figure 22. Exponential regression relationship between LST and bacteria at 20 September 2019.

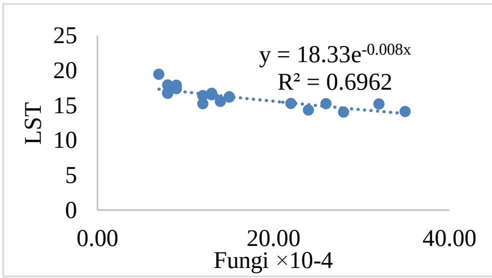

Figure 23. Exponential regression between LST and fungi at 20 September 2019.

Conclusions

The study reached the importance of Satellite Image in monitoring and evaluating the state of the Earth's surface and monitoring the effect of the growth and density of vegetation in the activity of microorganism, as they showed a statistical relationship between spectral indices and the number of bacteria and fungi. The study reached the importance of satellite image in calculating the temperature of the surface LST. Therefore, we recommend the importance monitoring of tempro-spatial changes in the state of vegetation and its spatial environment, thereby reducing the risks of desertification and its consequences and the need to conduct digital processing of Satellite Image by converting digital values into spectral reflection before calculating vegetation indices.

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